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ABSTRACT

In order to determine needs for teaching various competencies in agricultural mechanics courses, a study was conducted to determine the types and frequencies of service/repair operations performed by an Arizona agricultural machinery company from January 1 to June 30, 1981. Data were obtained from 1,232 service orders at the Arizona Machinery Company in Buckeye, Arizona, which services all types of farm machinery. Data were also gathered from interviews with the shop foreman, a field serviceman, and the sales manager. The study found that jobs involving power train, electrical, hydraulic, cooling, and air conditioning systems represented two-thirds of all tasks performed by mechanics at this major farm machinery dealership. Nearly two-thirds of all service orders received by the mechanics involved work conducted in-shop. Of the jobs performed in the field, nearly one-half involved air conditioning and hydraulics. More than two-thirds of all service orders involved work conducted on tractors. The implications of the study for vocational education are that agricultural mechanics in Arizona require a broad range of mechanical competencies and that, when developing specialized curricula for secondary or postsecondary programs in agricultural power and machinery, developers should pay attention to providing instruction that ensures that students have the opportunity to experience hands-on training. (A list of these competencies, the knowledge, and skills needed by agricultural mechanics make up a large part of this document.) (KC)

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AN ANALYSIS OF THE SKILLS REQUIRED

OF

AGRICULTURAL MECHANICS

AT RETAIL FARM MACHINERY DEALERSHIPS

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AN ANALYSIS OF THE SKILLS REQUIRED OF AGRICULTURAL MECHANICS AT RETAIL FARM MACHINERY DEALERSHIPS

INTRODUCTION

The purpose of vocational education is to prepare students for entry into and advancement in occupations of their choice. The success which students will enjoy in their occupations is, in large part, related to the quality of training they receive. Training of superior quality is carried out in a replica of the environment in which the student will later work. Training jobs must be carried out in the same way with the same operations, the same tools and the same equipment as in the occupation itself.

In order to provide such instruction, it is necessary to identify the knowledge and skills required in the occupations for which students are being prepared. To do so, studies must be conducted of the actual duties and operations carried out by people currently working in the field. Early efforts of this sort involved techniques of "job analysis" to develop detailed lists of skills necessary to perform a specific job. Techniques of job analysis were employed in this study using a primary source. In this instance, the primary source was service orders.

The emphasis of this report is to present data gathered in conducting a job analysis in the instructional taxonomy of agricultural mechanics. Agricultural mechanics is one of the seven components of the "Agricultural Business and Natural Resources" cluster identified by the Federal Office of Education.

This occupational area is of particular importance because, "instruction in agricultural mechanics is basic to all specialized programs in vocational agriculture," (Zurbrick, 1973). Zurbrick found that over 86 percent of the employees in all agricultural job titles required one or more skills in agricultural mechanics. Because the estimated number of persons employed in Arizona agriculture has risen from 19,445 in 1973 to 39,241 in 1982, it seems likely that the demand for training in agricultural mechanics has increased, and will continue to do so.

Consequently, the need for information regarding agricultural mechanics competencies is more pressing than ever. This need, coupled with a lack of time and resources has prompted researchers in the Department of Agricultural Education, The University of Arizona to utilize a direct approach to occupational studies by analyzing data obtained from retail agricultural machinery service records. The study was focused specifically on the agricultural power and machinery occupational cluster. This report will summarize the procedures involved and the data collected in this study.

PURPOSE OF THE STUDY

The primary purpose of the study was to determine the types and frequencies of service/repair operations performed by an Arizona agricultural machinery company for the period of January 1, 1981 to June 30, 1981.

OBJECTIVES

The following objectives were identified for the purpose of conducting this study:

1. To utilize service orders from the service center of the Arizona Machinery Company, Buckeye, Arizona to determine type and frequency of service/repair operations performed during the period of January 1, 1981 to June 30, 1981.
2. To record the data from the service orders according to type of implement and category of service/repair.
3. To conduct personal interviews with the shop foreman, field serviceman, and sales manager in order to assist in the interpretation of the data.
4. To evaluate the data compiled according to objectives one and two, and identify the nature of mechanical operations as performed by the service center of the Arizona Machinery Company for implications to the development of specialized vocational training programs in Arizona.

LIMITATIONS

The following factors were considered to be limitations of this study:

1. The study was conducted entirely at the Arizona Machinery Company, Buckeye, Arizona. Had the study been conducted at other machinery companies, the type and frequency of service/repairs reported in this publication may have been different.
2. The data for this study were obtained using service orders for the period January 1, 1981 to June 30, 1981. Thus, the study was delimited to that period of time.
3. The data concerning type and frequency of service/repairs recorded in this publication were taken from the actual information appearing on the service orders. No attempt was made to record service/repairs which may have been performed, but not itemized on service orders.

DEFINITIONS

The following terms, as defined below, were used in conducting and reporting this study:

Task: A unit of work activity or operation that constitutes a logical and necessary step in the performance of a duty (Vocational-Technical Education Consortium of States, 1980).

Service Order: A printed form on which performed tasks are recorded. It includes date, tasks performed, hours worked, parts required and total cost.

Traction Unit: Those system (e.g., fuel, electrical, power train) common to tractors and other self-propelled implements.

Primary Tillage Equipment: That equipment which works the soil for the entire depth of the root zone.

Secondary Tillage Equipment: That equipment which works the soil at the seedbed depth.

PROCEDURE

The Arizona Machinery Company in Buckeye, Arizona was selected as the sample agricultural machinery business to be used on this study. The Arizona Machinery Company was chosen because of its large size and because of the scope of service/repairs performed there. The service center of the Arizona Machinery Company in Buckeye services all the major types of farm machinery used in Arizona.

To obtain the data presented in this study, 1,232 orders were examined. These orders covered the period from January 1, 1981 to June 30, 1981. This period of time was selected at the advisement of the service manager. He considered it to be a representative sample of the type and volume of work normally performed during a six month period at the Arizona Machinery Company.

A service order is prepared each time agricultural machinery is serviced/ repaired at the Arizona Machinery Company. A typical service order details the make and model of machine, type of services rendered, hours of labor and location of service (i.e., shop or field).

A sampling of service orders was examined prior to initiating the collection of data in order to develop a log. The log was divided into sections. Each section listed major categories of service/repair for a specific category of machinery. Thus, tractors, harvesting equipment, primary tillage equipment, secondary tillage equipment, chemical applicators, planters and farmstead implements each had separate sections in the log.

The data were collected over a two week period. One person collected all the data in order to insure consistency. As each service order was examined, information was entered in the log according to the category of

machinery, location of service (i.e, field or shop) and type of service/repair. Frequencies of service/repair were recorded for specific tasks, as well as major categories of repairs. Only the information actually appearing on the service order was recorded. No attempt was made to record implied service/repairs.

After all service orders for the six month period had been reviewed and logged, the data were summarized. One hour interviews were then conducted with the shop foreman, a field serviceman and the sales manager. The interviews were conducted for the purpose of interpreting the data collected.

FINDINGS

Of the 1,232 service orders reviewed in this study, 318 were not used because they detailed non-service/repair transactions (e.g., sale of items from the shop inventory). Of the remaining 914 orders, 19 were non-revenue shop orders. That is, orders itemizing the use of personnel for shop maintenance and repair. The analysis of the remaining 895 orders, Table 1,

TABLE 1

Frequency and Percentage of Service by Categories of Machinery for Field, In Shop and Overall
N = 895

Machinery	Field		Shop		Total	
	No.	%	No.	%	No.	%
Harvesting Equipment*	9	1.00	43	4.8	52	5.8
Farmstead Implements	7	.80	4	.4	11	1.2
Cotton Picker	9	1.00	130	14.5	139	15.5
Chemical Applicators	0	0.00	13	1.5	13	1.5
Planters	3	.34	22	2.5	25	2.8
Tractor	307	34.30	300	33.5	607	67.8
Primary Tillage Equipment	1	.10	14	1.6	15	1.7
Secondary Tillage Equipment	<u>4</u>	<u>.45</u>	<u>29</u>	<u>3.2</u>	<u>33</u>	<u>3.7</u>
TOTAL	340	38.0**	555	62.0**	895	100.0**

*Not including cotton pickers.

**Rounded to nearest whole number.

indicated that 62 percent of the orders were for jobs done in-shop. The remaining 38 percent were for jobs conducted in the field. Of all jobs performed, 67.8 percent involved tractors. "Cotton pickers" were the second most frequently serviced category (15.5 percent) followed by other "harvesting equipment" (5.8 percent).

The major categories of service/repairs performed on tractors and the traction units of cotton pickers and other harvesting equipment are reported in Table 2. The term "traction unit" is used to connote those system (e.g., fuel, electrical, power train) common to these types of machinery and is employed here because it provides a suitable category for most of the service orders analyzed in this study.

The frequencies recorded in all tables refer to the number of times a task (e.g., replace a fuel line) or category of tasks (e.g., fuel system) was used.

Overall

As shown in Table 2, the five highest categories of service/repair were power train, electrical, hydraulic, cooling and air conditioning. Power train service/repair accounted for 17.0 percent of the tasks most frequently performed by agricultural mechanics at the Arizona Machinery Company. This figure is a total for service/repair to the five components of the power train, namely the clutch, transmission, differential, final drive and PTO. Electric service/repair accounted for 15.1 percent of the most commonly performed tasks. Hydraulic system service/repair followed third at 14.5 percent. Jobs involving the cooling system (11.3 percent) and air conditioning system (9.3 percent) ranked fourth and fifth, respectively. It is interesting to note that engine overhaul service/repair accounted for only 3.6 percent of all tasks. This finding is at odds with the common perception of an agricultural mechanic's duties.

Field and Shop

When the major categories were analyzed separately for field and in-shop service/repair, a slightly different picture emerged. For frequency of field calls, air conditioning ranked first (23.2 percent) followed by hydraulics (22.5 percent), power train (combined, 22.0 percent) and electrical (21.6 percent). Of the in-shop service/repair activities, the power train accounted for 22.1 percent, followed by electrical (12.2 percent), cooling (11.1 percent) and hydraulics (10.9 percent).

The next 16 tables show a more detailed listing of specific tasks performed by agricultural mechanics on the traction unit of self-propelled machinery. Each of the major categories of service/repair presented in Table 2 are broken into their component tasks. Again, the frequencies listed in these tables refer to tasks performed rather than number of service orders.

TABLE 2 -- Frequency and Percentage of Service/Repair for Tractors and The Traction Unit of Self Propelled Machinery

	Tractor						Cotton Picker						Harvesting Equipment**						Grand Total					
	Field		Shop		Total		Field		Shop		Total		Field		Shop		Total		Field		Shop		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Fuel System	29	7.7	39	7.2	68	7.4	0	--	9	2.8	9	2.7	0	--	1	2.4	1	1.6	29	7.0	49	5.4	78	5.9
Lubrication System	6	1.6	32	5.9	38	4.1	1	7.1	22	6.9	23	6.9	0	--	2	4.8	2	3.2	7	1.7	56	6.2	63	4.8
Cooling System	48	12.7	68	12.5	116	12.6	0	--	28	8.8	28	8.4	1	5	4	9.5	5	8.1	49	11.9	100	11.1	149	11.3
Brake System	0	--	12	2.2	12	1.3	0	--	34	10.7	34	10.2	0	--	1	2.4	1	1.6	0	--	47	5.2	47	3.6
Engine Overhaul	3	.8	37	6.8	40	4.3	0	--	5	1.6	5	1.5	0	--	2	4.8	2	3.2	3	.7	44	4.9	47	3.6
Air and Exhaust System	12	3.2	18	3.3	30	3.3	0	--	42	13.2	42	12.7	0	--	1	2.4	1	1.6	12	2.9	61	6.8	73	5.5
Air Conditioning System	86	22.7	21	3.9	107	11.6	0	--	3	.9	3	.9	10	50	3	7.0	13	21.0	96	23.2	27	3.0	123	9.3
Wheels	3	.8	19	3.5	22	2.4	0	--	2	.6	2	.6	0	--	0	--	0	--	3	.7	21	2.3	24	1.8
Electrical System	78	20.6	72	13.3	150	16.3	8	57.1	29	9.1	37	11.1	3	15	9	21.4	12	19.4	89	21.6	110	12.2	199	15.1
Clutch	2	.5	42	7.7	44	4.8	0	--	0	--	0	--	1	5	1	2.4	2	3.2	3	.7	43	4.8	46	3.5
Transmission	14	3.7	38	7.0	52	5.6	2	14.3	41	12.9	43	13.0	1	5	2	4.8	3	4.8	17	4.1	81	9.0	98	7.4
Differential	1	.3	14	2.6	15	1.6	0	--	0	--	0	--	0	--	0	--	0	--	1	.2	14	1.6	15	1.1
Final Drive	1	.3	21	3.9	22	2.4	3	21.4	22	6.9	25	7.5	1	5	2	4.8	3	4.8	5	1.2	45	5.0	50	3.8
PTO	1	.3	14	2.6	15	1.6	0	--	0	--	0	--	0	--	1	2.4	1	1.6	1	.2	15	1.7	16	1.2
Hydraulic System	90	23.7	64	11.8	154	16.7	0	--	28	8.8	28	8.4	3	15	6	14.3	9	14.5	93	22.5	98	10.9	191	14.5
Preparation	5	1.3	32	5.9	37	4.0	0	--	53	16.7	53	16.0	0	--	7	16.7	7	11.3	5	1.2	92	10.2	97	7.4
Total	379	100%	543	100%	922	100%	14	100%	318	100%	332	100%	20	100%	42	100%	62	100%	413	100%	903	100%	1,316	100%

* Rounded to nearest whole number.

** Excluding Cotton Pickers.

Power Train

Tables 3-8 detail service/repair to the various components of the power train. Table 3 shows service/repair to the differential of self-propelled implements. It is apparent from this table and the following four tables that very little transmission work was done in the field. One of the field servicemen indicated during an interview that the presence of dust and absence of necessary repair equipment generally precludes conducting transmission work in the field. As shown in Table 3, replacing bearings and ring gears were the two most common tasks in regard to the differential. It should

TABLE 3

Frequency and Percentage of Service/Repair on the
Differential for Tractors and the Traction
Unit of Self-propelled Machinery

Category of Service/Repair	Field		Shop		Total	
	No.	%	No.	%	No.	%
Bearings						
--Replace	1	50.0	3	14.3	4	18.2
--Set preload	0	0	1	4.8	1	4.5
Replace ring gear	0	0	4	19.0	4	18.2
Replace pinion shaft	0	0	2	9.5	2	9.1
Replace housing	0	0	1	4.8	1	4.5
Replace lock	0	0	1	4.8	1	4.5
Replace disc	0	0	1	4.8	1	4.5
Replace piston	0	0	1	4.8	1	4.5
Replace lock plates	0	0	1	4.8	1	4.5
Set backlash	0	0	1	4.8	1	4.5
Change thrust washers	0	0	1	4.8	1	4.5
Replace quill	1	50.0	2	9.5	2	9.1
Complete replacement	<u>0</u>	<u>0</u>	<u>2</u>	<u>9.5</u>	<u>2</u>	<u>9.1</u>
TOTAL	2	100.0*	21	100.0*	22	100.0*

*Rounded to nearest whole number.

be noted, however, that relatively few service/repair activities were made on the differential of self-propelled implements. Again, nearly all these jobs involved tractors. Total rebuilds were the most common task, representing 37.3 percent of all clutch jobs (see Table 4). Less than 6 percent of clutch jobs involved field service. Of this number, adjusting the clutch was the most frequently performed task.

TABLE 4

Frequency and Percentage of Service/Repair on the
Clutch for Tractors and the Traction Unit
of Self-propelled Machinery

Category of Service/Repair	Field		Shop		Total	
	No.	%	No.	%	No.	%
Replace disc	0	0	12	19.0	12	17.9
Replace seals	0	0	2	3.2	2	3.0
Replace bushings	0	0	1	1.6	1	1.5
Replace plate	0	0	5	7.9	5	7.5
Replace springs	0	0	7	11.1	7	10.4
Replace bearings	0	0	6	9.5	6	9.0
Replace damper	1	25.0	4	6.3	5	7.5
Adjust	3	75.0	1	1.6	4	6.0
Total rebuild	<u>0</u>	<u>0</u>	<u>25</u>	<u>39.7</u>	<u>25</u>	<u>37.3</u>
TOTAL	4	100.0*	63	100.0*	67	100.0*

*Rounded to nearest whole number.

Due to their complexity, transmissions contain more parts than any other component of the power train. Consequently, as can be seen in Table 5, the list of tasks is considerably longer. Changing the hydrostatic fluid and filter was the most common task. This task is commonly performed on cotton pickers during contractual overhauls. Replacing the transmission pump is also a relatively common transmission repair operation.

TABLE 5

Frequency and Percentage of Service/Repair on the
Transmission for Tractors and the Traction Unit
of Self-Propelled Machinery

Category of Service/Repair	Field		Shop		Total	
	No.	%	No.	%	No.	%
Hydrostatic motor						
--Rebuild	0	0	3	3.1	3	2.8
--Replace	1	9.1	0	0	1	.9
--Replace seals	0	0	5	5.1	5	4.6
Pump						
--Rebuild	0	0	1	1.0	1	.9
--Replace	0	0	10	10.2	10	9.2
--Replace input shaft	0	0	1	1.0	1	.9
--Replace coupler	0	0	1	1.0	1	.9
Top shaft						
--Replace	1	9.1	1	1.0	2	1.8
--Rebuild	0	0	1	1.0	1	.9
--Replace U-joint	0	9.1	0	0	1	.9
--Repair	0	0	9	9.2	9	8.3
Bottom shaft						
--Replace bearings	0	0	1	1.0	1	.9
--Replace collars	0	0	1	1.0	1	.9
--Replace U-joints	2	18.2	1	1.0	3	2.8
--Replace gears	0	0	1	1.0	1	.9
Shifting linkage						
--Adjust	1	9.1	2	2.0	3	2.8
--Replace retainer	1	9.1	0	0	1	.9
--Replace shaft	0	0	5	5.1	5	4.6
--Replace shifters	0	0	3	3.1	3	2.8
--Repair shift quadrant	0	0	2	2.0	2	1.8
--Replace shift cable	1	9.1	3	3.1	4	3.7
Rebuild two-speed pack	0	0	3	3.1	3	2.8
Front wheel drive shaft						
--Replace	0	0	1	1.0	1	.9
--Replace U-joints	0	0	1	1.0	1	.9
Replace drive line crosses	0	0	2	2.0	2	1.8
Replace rear yoke	1	9.1	0	0	1	.9
Replace reduction gear bearing retainer	1	9.1	0	0	1	.9
Clean sump strainer	0	0	5	5.1	5	4.6
Replace hydrostat reservoir	0	0	2	2.0	2	1.8
Replace hydrostat fluid/filter	0	0	29	29.6	29	26.6
Replace gaskets	0	0	2	2.0	2	1.8
Replace hydrostatic drive belts	0	0	1	1.0	1	.9
Install planetary drive shaft seal	1	9.1	0	0	1	.9
Replace transmission case	0	0	1	1.0	1	.9
TOTAL	11	100.0*	98	100.0*	109	100.0*

*Rounded to the nearest whole number.

Service/repair to the power take-off (PTO) was again made largely on tractors. The absolute number of such repairs was, however, relatively low. As shown in Table 6, replacing the rear seal and gasket were the two most common tasks performed.

TABLE 6

Frequency and Percentage of Service/Repair on the PTO
for Tractors and the Traction Unit
of Self-Propelled Machinery

Category of Service/Repair	Field		Shop		Total	
	No.	%	No.	%	No.	%
Replace shaft	0	0	1	4.3	1	4
Replace bearings	0	0	1	4.3	1	4
Replace disc	0	0	1	4.3	1	4
Replace plate	0	0	1	4.3	1	4
Replace oil lines	0	0	2	8.6	2	8
Replace rear seal	0	0	5	21.7	5	20
Replace rear gasket	0	0	3	13.0	3	12
Install O-ring	1	50	1	4.3	2	8
Replace front seal	0	0	1	4.3	1	4
Adjust linkage	0	0	1	4.3	1	4
Replace quill assembly	1	50	0	0	1	4
Brake						
--Repair	0	0	2	8.6	2	8
--Replace	0	0	3	13.0	3	12
Complete Rebuild	0	0	1	4.3	1	4
TOTAL	2	100.0*	23	100.0*	25	100.0*

*Rounded to the nearest whole number.

Repairs to the final drive of self-propelled implements were more common than those made on the PTO. It is interesting to note that, in this case, jobs were split about evenly between cotton pickers and tractors. As reported in Table 7, the most common service/repair jobs involved replacing seals and bearings (21.3 percent). Replacing shafts and couplers each represented 15.7 percent of all jobs performed on the final drive of self-propelled machinery.

TABLE 7

Frequency and Percentage of Service/Repair on the Final Drive
for Tractors and the Traction Unit
of Self-propelled Machinery

Category Service/Repair	Field		Shop		Total	
	No.	%	No.	%	No.	%
Replace seals/bearings	3	33.3	16	20.00	19	21.3
Housing						
--Replace	1	11.1	5	6.25	6	6.7
--Repair	1	11.1	0	0	1	1.1
Replace carrier	0	0	1	1.25	1	1.1
Recondition planetary pack	0	0	2	2.50	2	2.2
Replace gaskets	0	0	8	10.00	8	9.0
Axle						
--Replace	1	11.1	0	0	1	1.1
--Torque axle nuts	0	0	3	3.75	3	3.4
Replace output/input shaft	1	11.1	13	16.30	14	15.7
Replace couplers	0	0	14	17.50	14	15.7
Add oil	1	11.1	7	8.80	8	9.0
Replace spacer	1	11.1	1	1.30	2	2.2
Replace cup	0	0	2	2.50	2	2.2
Complete rebuild	0	0	8	10.00	8	9.0
TOTAL	9	100.0*	80	100.00*	89	100.0*

*Rounded to the nearest whole number.

As a concluding note on the power train, the reader should note that no mention is made of diagnostic tasks in the previous five tables. Trouble-shooting to locate defective parts was an inherent part of repair processes. Generally, field servicemen determined the general nature of the problem; service shop mechanics, then isolated the specific problem using the appropriate test equipment.

Electrical

As noted previously, overall electrical service/repairs accounted for 15.1 percent of the tasks most commonly performed by agricultural mechanics at the Arizona Machinery Company. Repairing lights ranked first overall for electrical repairs at 18.6 percent (See Table 8). This was a common overhaul item on cotton pickers. Ranking second was the replacement of batteries,

TABLE 8

Frequency and Percentage of Service/Repair on the Electrical System
for Tractors and the Traction Unit of
Self-Propelled Machinery

Category of Service/Repair	Field		Shop		Total		Category of Service/Repair	Field		Shop		Total	
	No.	%	No.	%	No.	%		No.	%	No.	%	No.	%
Alternator/Generator							Sending units						
--Replace	22	23.7	8	5.6	30	12.7	--Replace oil pressure	1	1.1	4	2.8	5	2.1
--Replace pulley	6	6.5	1	.7	7	3.0	--Replace engine	1	1.1	2	1.4	3	1.3
Battery							temperature						
--Replace cables	4	4.3	2	1.4	6	2.5	--Replace transmission	1	1.1	0	0	1	.4
--Replace	19	20.4	18	12.5	37	15.6	temperature						
--Service	2	2.2	4	2.8	6	2.5	Service/Replace plugs	0	0	1	.7	1	.4
Radio							Set points gap	0	0	1	.7	1	.4
--Install	0	0	9	6.3	9	3.8	Time	0	0	2	1.4	2	.8
--Repair	0	0	1	.7	1	.4	Install starting solenoid	0	0	2	1.4	2	.8
Injection Pump							Replace starter relay	2	2.2	3	2.1	5	2.1
--Repair wiring harness	0	0	1	.7	1	.4	Repair/Replace neutral	2	2.2	6	4.2	8	3.4
--Replace solenoid	1	1.1	1	.7	2	.8	start harness						
Repair lights	2	2.2	42	29.2	44	18.6	Replace neutral start	1	1.1	0	0	1	.4
Warning lights/gauges							switch						
--Replace oil pressure	1	1.1	0	0	1	.4	Replace ignition switch	6	6.5	3	2.1	9	3.8
gauge							Replace wiring harness	0	0	3	2.1	3	1.3
--Replace oil pressure	0	0	1	.7	1	.4	Install circuit breaker	3	3.2	0	0	3	1.3
indicator light							Replace guide wheel switch	0	0	8	5.6	8	3.4
--Replace fuel gauge	0	0	3	2.1	3	1.3	Replace cab relay	0	0	4	2.8	4	1.7
--Replace engine tem-	1	1.1	1	.7	2	.8	Monitor sensor						
perature gauge							--Adjust	0	0	2	1.4	2	.8
--Replace hour water	1	1.1	3	2.1	4	.7	--Replace	0	0	1	.7	1	.4
Starter													
--Replace	6	6.5	0	0	6	2.5	Total	93	100%*	144	100%*	237	100%*
Air Conditioning													
--Install thermostat	4	4.3	1	.7	5	2.1							
switch													
--Repair/Replace wiring	6	6.5	4	2.8	10	4.2							
--Replace circuit	1	1.1	1	.7	2	.8							
breaker													
--Replace thermal fuse	0	0	1	.7	1	.4							

*Rounded to nearest whole number.

followed by the replacement of alternators and generators. Implied in these tasks are many other skills which, while not listed, are equally important. Chief among these is the ability to troubleshoot an electrical system. To do so requires, among others, the ability to read schematics, use reference manuals, and operate voltmeters, ammeters, and ohmmeters. Consequently, when interpreting the data, tasks such as replacing batteries should be viewed as the last in a series of tasks. "Replacing a battery" suggests that a mechanic performed several tasks in order to identify the defective battery.

When data were analyzed separately for in-shop, the ranking of electrical tasks by frequency of occurrence was largely the same. When data were analyzed for field services only, the replacement of various electrical components ranked very high. The replacement of alternators and generators ranked first at 23.7 percent of all electrical field tasks followed by replacement of batteries at 20.4 percent.

Air Conditioning System

Table 9 shows the categories of service/repair for air conditioning. Air conditioning service/repairs were the most frequently performed tasks

TABLE 9

Frequency and Percentage of Service/Repair on the Air Conditioning System for Tractors and the Traction Unit of Self-propelled Machinery

Category of Service/Repair	Field		Shop		Total	
	No.	%	No.	%	No.	%
Charge with freon	76	27.4	16	34.8	92	28.5
Evacuate	70	25.3	6	13.0	76	23.5
Replace expansion valve	10	3.6	0	0	10	3.1
Replace dryer	21	7.6	3	6.5	24	7.4
Replace lines	12	4.3	0	0	12	3.7
Replace hoses	7	2.5	0	0	7	2.2
Evaporator						
--Replace	0	0	1	2.2	1	.3
--Clean	2	.7	2	4.3	4	1.2
Condenser						
--Replace	0	0	1	2.2	1	.3
--Clean	1	.4	0	0	1	.3
Compressor						
--Replace	46	16.6	6	13.0	52	16.1
--Repair	3	1.1	1	2.2	4	1.2
--Install belt	13	4.6	1	2.2	14	4.3
--Repair clutch	1	.4	0	0	1	.3
--Replace O-rings	2	.7	2	4.3	4	1.2
Blower						
--Replace motor	13	4.6	7	15.2	20	5.2
TOTAL	277	100.0*	46	100.0*	323	100.0*

*Rounded to the nearest whole number.

by field servicemen. Not including troubleshooting procedures such as routine pressure testing and refrigerant leak detection, charging with freon was the most frequently performed task. Evacuating the system accounted for 23.5 percent of service/repair operation. Both of these tasks must be performed any time the system is opened. Replacing the compressor was third at 16.1 percent. It is interesting to note that many of the air conditioning tasks involve the replacement of parts. It was also noted that approximately 70 percent of the reported tasks were conducted in the field.

Hydraulic System

Table 10 shows the categories of service/repairs for the hydraulic systems of self-propelled implements. Changing the fluid and filter was the most frequently reported task. Overall, it accounted for 19.4 percent of all hydraulic service/repair activities. Performance of these jobs was expected as this service is commonly conducted during contractual cotton picker overhauls.

Other frequently performed tasks included replacing tubing and hose, repairing couplers and adjusting valves. Additional tasks are again implied for many of these jobs. Replacing hose, for example, suggests that the mechanics first cut the hose to the proper length and attached the appropriate fitting. Nearly all the replacement tasks, such as the replacement of a hydraulic pump, suggest that troubleshooting skills were initially employed to isolate the defective part. These skills include the ability to use test equipment and service/repair manuals. Tasks detailing the overhaul of pumps and cylinders also suggest additional unlisted tasks, such as using micrometers to determine equipment wear. Again, the reader is urged to view each of the listed tasks as the last in a series of tasks.

When data were analyzed separately for field/service repairs, changing the fluid and filter, and replacing hose and pipe each accounted for 12.9 percent of all field hydraulic service/repair. Adjusting valves on the rockshaft housing was also a relatively common task.

Cooling System

As noted previously, service/repairs to the cooling system of self-propelled implements were listed as 11.3 percent of all service orders written during the first six months of 1981. As shown in Table 11, 32 percent of the cooling system tasks recorded on these orders involved rebuilding water pumps. Replacing fan belts was also a common task, especially in the field. Not included in this table are various troubleshooting tasks such as pressure testing the system.

TABLE 10

Frequency and Percentage of Service/Repair on the Hydraulic System
for Tractors and the Traction Unit
of Self-Propelled Machinery

Category of Service/Repair	Field		Shop		Total		Category Service/Repair	Field		Shop		Total	
	No.	%	No.	%	No.	%		No.	%	No.	%	No.	%
Main Pump							Steering Motor						
--Replace	1	1.6	1	.8	2	1.1	--Replace bearings	0	0	2	1.6	2	1.1
--Reseal	3	4.8	3	2.4	6	3.2	--Replace mounts	0	0	5	4.0	5	2.7
--Repair central shaft	1	1.6	0	0	1	.5	Breakaway Couplers						
--Replace O-rings	1	1.6	1	.8	2	1.1	--Install	0	0	4	3.2	4	2.1
--Install bushings	0	0	1	.8	1	.5	--Repair	5	8.1	5	4.0	10	5.3
--Rebuild	0	0	3	2.4	3	1.1	Selective Control Valve						
--Replace belt	0	0	8	6.3	8	4.3	--Rebuild	0	0	8	6.3	8	4.3
Implement Control							--Install	2	3.2	6	4.8	8	4.3
--Adjust valves on	7	11.3	3	2.4	10	5.3	--Adjust linkage	1	1.6	1	.8	2	1.1
rockshaft housing							--Repair coupler	1	1.6	0	0	1	.5
--Replace rockshaft	0	0	3	2.4	3	1.1	Main valve						
--Replace rockshaft	0	0	1	.8	1	.5	--Replace	0	0	1	.8	1	.5
housing							--Reseal	0	0	1	.8	1	.5
--Repair valve linkage	2	3.2	1	.8	3	1.1	Change fluid/filter	8	12.9	30	23.8	38	20.2
--Adjust linkage	3	4.8	0	0	3	1.1	Adjust pressure	6	9.7	3	2.4	9	4.8
--Reseal piston	1	1.6	1	.8	2	1.1	Hoses/Pipe						
--Replace serve cam	0	0	1	.8	1	.5	--Replace	8	12.9	3	2.4	11	5.3
and lock bolt							Remote Cylinder						
--Replace bushings	0	0	3	2.4	3	1.1	--Reseal	1	1.6	0	0	1	.5
and seals							--Rebuild	0	0	2	1.6	2	1.1
Steering Valve							--Replace	0	0	1	.8	1	.5
--Replace	1	1.6	5	4.0	6	3.2	Replace feedback cylinder	0	0	2	1.6	2	1.1
--Adjust	0	0	1	.8	1	.5	Miscellaneous	4	6.5	6	4.8	10	5.3
--Rebuild	1	1.6	0	0	1	.5							
--Redaim valve seats	0	0	3	2.4	3	1.1	Total	62	100%*	126	100%*	188	100%*
Steering Cylinder													
--Replace	0	0	1	.8	1	.5							
--Rebuild	1	1.6	1	.8	2	1.1							
--Reseal	3	4.8	2	1.6	5	2.1							
Steering Pump													
--Reseal	1	1.6	2	1.6	3	1.1							
--Replace	0	0	1	.8	1	.5							

TABLE 11

Frequency and Percentage of Service/Repair on the Cooling
System for Tractors and the Traction Unit
on Self-propelled Machinery

Category of Service/Repair	Field		Shop		Total	
	No.	%	No.	%	No.	%
Check coolant level/solution	2	3.6	8	6.6	10	5.6
Water pump						
--Rebuild	0	0	57	46.7	57	32.0
--Install	9	16.1	0	0	9	5.0
--Install guard	0	0	8	6.6	8	4.5
Radiator						
--Clean	4	7.1	13	10.7	17	9.6
--Replace	4	7.1	0	0	4	2.2
--Repair	4	7.1	6	4.9	10	5.6
--Install baffle kit	2	3.6	0	0	2	1.1
--Replace cap	2	3.6	1	.8	3	1.7
Fan						
--Replace bearings	0	0	1	.8	1	.6
--Replace belt	16	28.6	10	8.2	26	14.6
--Replace pulley	4	7.1	5	4.1	9	5.0
--Replace shroud	0	0	2	1.6	2	1.1
Replace thermostat	6	10.7	1	.8	7	3.9
Replace hoses	3	5.4	10	8.2	13	7.3
TOTAL	56	100.0*	122	100.0*	178	100.0*

*Rounded to the nearest whole number.

Preparation

Preparation activities to self-propelled machinery, such as set-up of machinery, cleaning and painting, ranked fifth overall for frequency of occurrence. During the first six months of 1981, 7.4 percent of all service orders listed preparation activities. As can be seen in Table 12, most frequent preparation task was steam cleaning/washing, followed by painting. Most of these tasks were performed on cotton pickers brought in to be overhauled.

TABLE 12

Frequency and Percentage of Preparation Activities
for Tractors and the Traction Unit
of Self-propelled Machinery

Category of Service/Repair	Field		Shop		Total	
	No.	%	No.	%	No.	%
Set-up	0	0	5	3.4	5	3.3
Steam clean/wash	5	100.0	87	60.0	92	61.3
Paint	<u>0</u>	<u>0</u>	<u>53</u>	<u>36.6</u>	<u>53</u>	<u>35.3</u>
TOTAL	5	100.0	145	100.0	150	100.0*

*Rounded to the nearest whole number.

Fuel System

Table 13 details service/repair on the fuel system of self-propelled machinery. Eighty-seven percent of the tasks listed in this table were performed on tractors. Replacing the injection pump was the most common fuel repair, overall (18.6 percent). It should be noted that 63 percent of the injection pumps were replaced in the field. Ranking second, overall, for frequency of occurrence was replacing injectors (10.8 percent) in which 54.5 percent were replaced in the field. Timing the injection pump to the engine was inherently a part of replacement and not reported as such.

Lubrication

Table 14 summarizes the data on the lubrication system of self-propelled machinery. As one would expect, changing the oil and filter was by far the most common lubrication task performed by mechanics of the Arizona Machinery Company.

TABLE 13

Frequency and Percentage of Service/Repair on the Fuel
System for Tractors and on the Traction Unit
of Self-propelled Machinery

Category of Service/Repair	Field		Shop		Total	
	No.	%	No.	%	No.	%
Rebuild Carburetor	0	0	1	1.7	1	1.0
Fuel Line						
--Install	0	0	3	5.0	3	3.0
--Install boots	1	2.4	1	1.7	2	2.0
--Replace bleedline screen	1	2.4	0	0	1	1.0
Replace check valve	0	0	1	1.7	1	1.0
Throttle						
--Repair	2	4.8	5	8.3	7	6.9
--Adjust	2	4.8	3	5.0	5	4.9
Injection Pump						
--Repair	0	0	4	6.7	4	4.0
--Replace	12	28.6	7	11.7	19	18.6
--Time	4	9.5	4	6.7	8	7.8
Fuel Transfer Pump						
--Replace	2	4.8	1	1.7	3	3.0
--Replace primer	1	2.4	1	1.7	2	2.0
--Replace gasket	0	0	1	1.7	1	1.0
--Replace O-ring	1	2.4	0	0	1	1.0
Filter						
--Replace	7	16.7	2	3.3	9	8.8
Injectors						
--Replace line	0	0	6	10.0	6	5.9
--Replace washers	1	2.4	7	11.7	8	7.9
--Replace	6	14.3	5	8.3	11	10.8
Fuel Tank						
--Repair	0	0	3	5.0	3	3.0
--Replace	2	4.8	5	8.3	7	6.9
TOTAL	42	100.0*	60	100.0*	102	100.0*

*Rounded to the nearest whole number.

TABLE 14

Frequency and Percentage of Service/Repair on the Lubrication
System for Tractors and the Traction Unit
of Self-propelled Machinery

Category of Service/Repair	Field		Shop		Total	
	No.	%	No.	%	No.	%
Change oil/filter	1	16.7	41	71.9	42	66.7
Adjust oil pressure	2	33.3	0	0	2	3.2
Take oil sample	0	0	6	10.5	6	9.5
Oil pump						
--Replace inlet tube	1	16.7	0	0	1	1.6
--Rebuild	0	0	1	1.8	1	1.6
--Install	0	0	1	1.8	1	1.6
--Replace drive assembly	0	0	1	1.8	1	1.6
Oil pan						
--Replace gasket	1	16.7	4	7.0	5	7.9
--Clean	1	16.7	1	1.8	2	3.2
Oil cooler						
--Replace valve tee	0	0	1	1.8	1	1.6
--Replace O-ring	0	0	1	1.8	1	1.6
TOTAL	6	100.0*	57	100.0*	63	100.0*

*Rounded to nearest whole number.

Engine Overhaul

Engine overhaul service/repair constituted only 3.6 percent of all service orders from January 1, 1981 to June 30, 1981. The type of activities that most lay people would ascribe to an agricultural mechanic, such as replacing pistons and cylinder sleeves, actually occupied a rather low percentage of a mechanic's time. Of the engine repair operations reported in Table 15, valve jobs accounted for approximately one-third of all tasks performed. Major overhaul activities, such as replacing pistons and sleeves were relatively infrequent.

TABLE 15

Frequency and Percentage of Engine Overhaul Service/Repair
for Tractors and the Traction Unit
of Self-propelled Machinery

Category of Service/Repair	Field		Shop		Total	
	No.	%	No.	%	No.	%
Replace piston	0	0	8	9.6	8	9.2
Replace cylinder sleeves	0	0	9	10.8	9	10.3
Connecting rods						
--Replace	0	0	6	7.2	6	6.9
--Rebush	0	0	1	1.2	1	1.1
--Replace bolts	1	25.0	0	0	1	1.1
Head						
--Mill	0	0	3	3.6	3	3.4
--Replace gasket	0	0	8	9.6	8	9.2
--Replace	1	25.0	0	0	1	1.1
Replace camshaft	0	0	3	3.6	3	3.4
Replace crankshaft	0	0	1	1.2	1	1.1
Valve job	0	0	28	33.7	28	32.2
Replace rocker arm	1	25.0	0	0	1	1.1
Install push rod	1	25.0	0	0	1	1.1
Install short block	0	0	6	7.2	6	6.9
Replace front engine seal	0	0	3	3.6	3	3.4
Replace rear engine seal	0	0	7	8.4	7	8.0
TOTAL	4	100.0*	83	100.0*	87	100.0*

*Rounded to the nearest whole number.

Exhaust, Brakes and Wheels

Table 16, 17 and 18 summarize the data for the air and exhaust system, break system and wheels, respectively. All three systems ranked low overall for frequency of service/repair. As can be seen in Table 16, replacing the air filter was by far the most frequent task performed by agricultural mechanics on the air and exhaust system (68.9 percent). Installing aspirators ranked second (14.9 percent). In regard to the brake system, adjusting brakes represented 48.3 percent of the service/repair jobs accompanied by complete repair of brakes at 20.7 percent. These tasks were performed most frequently on cotton pickers.

TABLE 16

Frequency and Percentage of Service/Repair on the Air and Exhaust System
for Tractors and the Traction Unit of Self-propelled Machinery

Category of Service/Repair	Field		Shop		Total	
	No.	%	No.	%	No.	%
Replace air cleaner	0	0	51	75.0	51	68.9
Clean air filter	1	16.7	0	0	1	1.4
Muffler						
--Replace	0	0	1	1.5	1	1.4
--Install rain cap	0	0	1	1.5	1	1.4
--Install extension	0	0	1	1.5	1	1.4
Exhaust manifold						
--Replace gasket	1	16.7	0	0	1	1.4
Turbocharger						
--Replace	3	50.0	0	0	3	4.1
--Install aspirator	0	0	11	16.2	11	14.9
--Install flex hose	0	0	1	1.5	1	1.4
--Install turbocharger- manifold coupler	1	16.7	0	0	1	1.4
Install crankcase outlet valve	0	0	2	2.9	2	2.7
TOTAL	6	100.0*	68	100.0*	74	100.0*

*Rounded to nearest whole number.

Table 17

Frequency and Percentage of Service/Repair on the Brake System for
Tractors and the Traction Unit of Self-propelled Implements

Category of Service/Repair	Field		Shop		Total	
	No.	%	No.	%	No.	%
Adjust	0	0	28	48.3	28	48.3
Replace pads	0	0	2	3.4	2	3.4
Replace disc	0	0	9	15.5	9	15.5
Replace piston	0	0	2	3.4	2	3.4
Replace line	0	0	1	1.7	1	1.7
Reline	0	0	2	3.4	2	3.4
Replace springs	0	0	2	3.4	2	3.4
Rebuild (complete)	0	0	12	20.7	12	20.7
TOTAL	0	0	58	100.0*	58	100.0*

*Rounded to nearest whole number.

Table 18 details wheel related tasks. As shown, adjusting wheel spacing was the most frequent task (27 percent), followed closely by mounting duals (20.1 percent) and filling tires with ballast (16.7 percent). All of the tasks, except two, recorded in Table 18 were performed on tractors.

TABLE 18

Frequency and Percentage of Wheel-related Service/Repair
for Tractors and the Traction Unit
of Self-propelled Machinery

Category Service/Repair	Field		Shop		Total	
	No.	%	No.	%	No.	%
Adjust spacing	0	0	14	29.2	14	27.0
Mount duals	0	0	10	20.1	10	19.2
Remove duals	0	0	2	4.2	2	3.8
Fill with ballast	0	0	8	16.7	8	15.3
Replace sleeve half	1	25.0	0	0	1	1.9
Install tubes	0	0	1	2.1	1	1.9
Replace hub	0	0	1	2.1	1	1.9
Drill lugs	0	0	1	2.1	1	1.9
Change tires	0	0	3	6.3	3	5.7
Repair tires	0	0	1	2.1	1	1.9
Align front wheels	1	25.0	0	0	1	1.9
Install wheel weights	0	0	5	10.4	5	9.6
Replace front wheel spindle	0	0	1	2.1	1	1.9
Replace bearings	1	25.0	0	0	1	1.9
Pack bearings	1	25.0	0	0	1	1.9
Replace wheel	0	0	1	2.1	1	1.9
TOTAL	4	100.0*	48	100.0*	52	100.0*

*Rounded to the nearest whole number.

The data presented thus far have related primarily to tractors and the traction units of self-propelled machinery. As stated at the outset, this classification includes most of the data collected. In addition to this, information was also gathered on various agricultural implements such as the harvesting units of machines involved in the cutting, gathering and/or conditioning of crops in the field. Tables 19 through 25 summarize this data.

Planters

As noted in Table 1, 25 service orders involved service/repair to planters. The tasks listed on these orders are listed in Table 19. As shown, the most frequent task is set-up--that is, the actual assembly of planters (34.9 percent). Installing monitors accounted for 16.3 percent of the planter activities. Most of the service/repair listed in this table is performed on new or used planters being prepared for sale. Very little work is done on

TABLE 19

Frequency and Percentage of Service/Repair for Planters

Category of Service/Repair	Field		Shop		Total	
	No.	%	No.	%	No.	%
Set-up	0	0	15	37.5	15	34.9
Adjust	0	0	3	7.5	3	7.0
Row Conversion	0	0	3	.5	3	7.0
Monitors						
--Install	0	0	7	17.5	7	16.3
--Replace Sensor	0	0	3	7.5	3	7.0
--Replace Harness	1	33.3	2	5.0	3	7.0
--Repair	0	0	1	2.5	1	2.3
Install Disc Cappers	0	0	1	2.5	1	2.3
Replace Gauge Wheel Crank	1	33.3	0	0	1	2.3
Replace Closing Wheel	1	33.3	0	0	1	2.3
Hydraulic System	0	0	1	2.5	1	2.3
Install Tubes	0	0	1	2.5	1	2.3
Install Levers on Seeder Boxes	0	0	1	2.5	1	2.3
Install Drag Chains	0	0	1	2.5	1	2.3
Install Grass Seeder	0	0	1	2.5	1	2.3
TOTAL	3	100.0*	40	100.0*	43	100.0*

*Rounded to the nearest whole number.

planters by Arizona Machinery Company mechanics after they have been sold. Both the sales manager and a field serviceman indicated during interviews that farmers generally repair, service and adjust planters themselves.

Primary Tillage Equipment

Machinery classified as primary tillage equipment includes the moldboard, plow, plowdisk, chisel plow and subsoiler. During the first six months of 1981, 15 service orders were identified which listed service/repair to such equipment. As shown in Table 20, service/repair to the hydraulic system was the task most frequently performed by agricultural mechanics. These tasks involved rebuilding or replacing the remote hydraulic cylinder. Ranking

TABLE 20

Frequency and Percentage of Service/Repair
for Primary Tillage Equipment*

Category of Service/Repair	Field		Shop		Total	
	No.	%	No.	%	No.	%
Set-up	0	0	6	15.0	6	14.6
Prep	0	0	5	12.5	5	12.2
Hydraulic System	1	100	6	15.0	7	17.1
Replace Moldboard	0	0	5	12.5	5	12.2
Replace Shin	0	0	3	7.5	3	7.3
Replace Landside	0	0	5	12.5	5	12.2
Replace Frog	0	0	3	7.5	3	7.3
Replace Trash boards	0	0	3	7.5	3	7.3
Replace Shanks	0	0	1	2.5	1	2.4
Replace Shank points	0	0	1	2.5	1	2.4
Miscellaneous	0	0	2	5.0	2	4.9
TOTAL	1	100.0**	40	100.0**	41	100.0**

* Disk plow, moldboard plow, ripper, chisel plow.

**Rounded to nearest whole number.

second for frequency of occurrence was set-up. Again, as with planters, very little work is done on primary tillage equipment by agricultural mechanics after it is sold. Less than three percent of service/repair work was conducted in the field.

Secondary Tillage Equipment

Secondary tillage machinery is equipment which works the soil at seed-bed depth (see Table 21). Examples include harrows and cultivators. Ranking first for the task most frequently performed on secondary tillage equipment was set-up (62.5 percent). Less than 12 percent of all service/repair involving secondary tillage equipment were performed in field.

TABLE 21

Frequency and Percentage of Service/Repair
for Secondary Tillage Equipment*

Category of Service/Repair	Field		Shop		Total	
	No.	%	No.	%	No.	%
Set-up	0	0	20	71.43	20	62.5
Electrical System	2	50	0	0	2	6.3
Hydraulic System	0	0	4	14.29	4	12.5
Install Stop Kit	2	50	1	3.57	3	9.4
Install Sweeps	0	0	1	3.57	1	3.1
Miscellaneous	<u>0</u>	<u>0</u>	<u>2</u>	<u>7.14</u>	<u>2</u>	<u>6.3</u>
TOTAL	4	100.0*	28	100.0*	32	100.0*

*Disk Harrow, cultivator, vari-trak, thinner, mulcher, flex roller, landplane, pegger, border disc, bed shaper.

**Rounded to nearest whole number.

Farmstead Equipment

Table 22 summarizes the data for service/repair on farmstead equipment. As noted, this classification is used to refer to grinder/mixers, elevators, post hole diggers, carryalls and rear blades. Once again, set-up is the most frequently performed task accounting for 41.2 percent of all jobs involving farmstead equipment.

TABLE 22

Frequency and Percentage of Service/Repair for Farmstead Equipment*

Category of Service/Repair	Field		Shop		Total	
	No.	%	No.	%	No.	%
Set-up	0	0	7	53.8	7	41.2
Prep	0	0	1	7.7	1	5.9
Wheel	2	50	1	7.7	3	17.6
Replace Axle	1	25	0	0	1	5.9
Miscellaneous	<u>1</u>	<u>25</u>	<u>4</u>	<u>30.8</u>	<u>5</u>	<u>29.4</u>
TOTAL	4	100	13	100.0	17	100.0

*Grinder/Mixer, Elevator, Post Hole Digger, Carryall, Rear Blade

Chemical Applicators

A small percentage of service orders (1.5 percent) during the period of January 1, 1981 to June 30, 1981 involved service/repair on chemical applicators. All of the tasks recorded were performed in-shop. As shown in Table 23, only two tasks were performed: rebuilding solution pumps (64.3 percent) and rebuilding hydraulic motors (35.7 percent).

TABLE 23

Frequency and Percentage of Service/Repair for Chemical Applicators

Category of Service/Repair	Field		Shop		Total	
	No.	%	No.	%	No.	%
Rebuild Hydraulic Motor	0	0	5	35.7	5	35.7
Rebuild Pump	<u>0</u>	<u>0</u>	<u>9</u>	<u>64.3</u>	<u>9</u>	<u>64.3</u>
TOTAL	0	0	14	100.0	14	100.0

Cotton Picker Picking Unit

Table 24 summarizes the data for the picking unit, unit drive, water system and air system of the cotton picker. All other service/repair to cotton pickers were quantified in the tables covering the traction units of self-propelled implements.

TABLE 24

Frequency and Percentage of Service/Repair for
Cotton Picker Picking Unit, Unit Drive
Water System and Air System*

Category of Service/Repair	No.	%		No.	%
Disassemble Picker Head	53	4.3	Water System		
Steam Clean	53	4.3	--Recondition Moistener	53	4.3
Paint	53	4.3	Column		
Lube	53	4.3	--Set Moistener Columns	53	4.3
Grid Bars			--Rebuilt Unit Water Pump	5	.4
--Replace/Align	25	2.0	--Replace Unit Water Pump	5	.4
Spindles/Bushings			--Install Water Pump	34	2.8
--Replace	49	4.0	Restraint Kit		
Picker Bars			Pressure Plates		
--Replace Bushings/Studs	43	3.5	--Recondition	23	1.9
--Level	53	4.3	--Replace	10	.8
--Recondition	48	3.5	--Replace Flaps	22	1.8
--Install Sleeves	21	1.7	Air System		
--Replace Cam Arms	11	.9	--Replace Air Ducts	36	2.9
Picker Drum			--Replace Blower Belt	23	1.9
--Replace Heads	31	2.5	Unit Drive Countershaft		
--Replace Grease Tubes	48	3.9	--Replace Belts	8	.7
--Recondition Heads	16	1.3	--Replace Countershaft	3	.2
Drum Shaft and Gears			--Replace U-joints	8	.7
--Replace Top Drive Gear	13	1.1	Cabinet		
--Replace Sun Gears	32	2.6	--Replace Wear Angles	26	2.1
Idler Gears and Bearings			--Hardface Skid Plates	21	1.7
--Replace	15	1.2	--Repair Stalk Lifters	2	.2
Doffer			--Replace Seals and Bearings	53	4.3
--Recondition	53	4.3	Run in Head	53	4.3
--Align	53	4.3	Adjust Head in Field	53	4.3
--Replace Drive Chain	16	1.3			
			TOTAL	1,230	100.0*

*Rounded to the nearest whole number.

During the first six months of 1981, 139 service orders were prepared detailing service/repair on cotton pickers. Most of these service orders summarized contractual overhauls. Each year, cotton growers meet with Arizona Machinery Company personnel. At that time, they are presented with a contract listing selected service/repair which will be performed on cotton pickers for a given price. Growers select from this list those service/repairs they wish to be performed. Cotton pickers are then overhauled in accordance with this contract.

From January 1, 1981 to June 30, 1981, 53 pickers were enrolled in the contractual overhaul program. Two service orders were prepared on each picker overhauled--one for the head (picking unit) and one for everything behind the head. Therefore, 106 service orders detailed contractual overhaul work. The remaining 33 service orders (139 - 106 = 33), involved non-contractual work on cotton pickers, including repair of component parts such as water pumps.

As can be seen in Table 24, several tasks were performed everytime the picking unit, unit drive, water system and air system of a cotton picker were overhauled. The head was disassembled, cleaned and painted. Picker bars were leveled, doffers reconditioned and aligned. Moistener columns were reconditioned and set, and all cabinet seals and bearings replaced. When the job was completed and the head assembled, all pickers were started ("run-in" the head) and adjusted. As shown in Table 24, various other tasks were done in varying frequencies depending upon the condition of the cotton picker.

Combine Picking Unit

Table 25 details the tasks performed on the heads of combines during the first six months. It is apparent from this table that very little work was done in this area. The same holds true for the harvesting units of cubers and swathers. No more than four tasks were recorded involving these units during the first six months of 1981.

Shop Maintenance

At the outset of this section of the report, it was mentioned that 19 service orders during the period of January 1, 1981 to June 30, 1981 summarized non-revenue shop maintenance and repair. The information on those orders is summarized in terms of man hours in Table 26. It is interesting to note the amount of a mechanic's time involved in shop maintenance--that is, the repair of shop facilities and equipment--and clean up. A mechanic spends, quite literally, days involved in such activity each year. Similar activity in vocational training programs may have more educational value than has been assumed.

TABLE 25

Frequency and Percentage of Picking Unit
Service/Repairs on Combines

Category of Service/Repair	Field		Shop		Total	
	No.	%	No.	%	No.	%
Attach head	--	--	1	10	1	9.1
Adjust cylinder speed	1	100	0	0	1	9.1
Replace rasp bars	--	--	1	10	1	9.1
Replace beater	--	--	1	10	1	9.1
Replace rear cross auger	--	--	1	10	1	9.1
Replace auger drive countershaft	--	--	1	10	1	9.1
Replace auger drive bearings	--	--	1	10	1	9.1
Tighten cable on unloading auger	--	--	1	10	1	9.1
Set-up platform	--	--	3	30	3	27.3
TOTAL	1	100*	10	100*	11	100.0*

*Rounded to nearest whole number.

TABLE 26

Manhours of General Shop Work by
Category of Service/Repair

Category of Service/Repair	Hours
Shop Maintenance	102.5
Vehicle Repair	301.4
Clean Up	<u>168.8</u>
TOTAL	572.7

Summary of Findings

The following list summarizes the major findings of this study:

1. Of all service orders examined for the sixth month period identified for this study, 62 percent were for service/repair work performed in-shop. The balance, or 38 percent, were written for service/repair requiring work to be performed in the field.
2. Work performed on tractors constituted 67.8 percent of the service orders, while 15.5 percent of all service orders involved work performed on cotton pickers.
3. The following frequencies and percentages of activities were identified by major category of service/repair for tractors and the traction units of self-propelled machinery using 1,232 service orders.

Power Train (combined)	- 225 service orders	(17.0%)
Electrical System	- 199 service orders	(15.1%)
Hydraulic System	- 191 service orders	(14.5%)
Cooling System	- 149 service orders	(11.3%)
Air Conditioning System	- 123 service orders	(9.3%)

4. Of 413 field service orders, 23.7 percent were for the air conditioning system, 22.5 percent for the hydraulic system and 21.6 percent for the electrical system.
5. Engine overhaul operations accounted for less than 4.0 percent of all service/repair activities recorded by the service department.
6. Of the 225 service orders involving the power train of tractors and the traction unit of self-propelled machinery, 43.6 percent involved the transmission, 22.2 percent involved the final drive, 20.4 percent involved the clutch, 7.1 percent involved the PTO and 6.7 percent involved the differential.
7. Of the 109 transmission tasks, the most commonly performed were:
 - Replace hydrostat fluid/filter - 29 service orders (26.6%)
 - Replace pump - 10 service orders (9.2%)
8. Of the 89 final drive tasks, the most commonly performed were:
 - Replace seals/bearings - 19 tasks (21.3%)
 - Replace output/input shaft - 14 tasks (15.7%)
 - Replace couplers - 14 tasks (15.7%)
9. Of the 67 clutch tasks, the most commonly performed were:
 - Total rebuild - 25 tasks (37.3%)
 - Replace disc - 12 tasks (17.9%)

10. Of the 25 PTO tasks, the most commonly performed were:
- Replace rear seal - 5 tasks (20.0%)
 - Replace rear gasket - 3 tasks (12.0%)
11. Of the 22 differential tasks, the most commonly performed were:
- Replace bearings - 4 tasks (18.2%)
 - Replace ring gear - 4 tasks (18.2%)
12. Of the 237 electrical tasks, the most commonly performed were:
- Repair lights - 44 tasks (18.6%)
 - Replace battery - 37 tasks (15.6%)
 - Replace alternator/generator - 30 tasks (12.7%)
13. Of the 196 hydraulic tasks, the most commonly performed were:
- Change fluid/filter - 38 tasks (19.4%)
 - Replace hose/pipe - 11 tasks (5.6%)
 - Repair breakaway couplers - 10 tasks (5.1%)
 - Adjust valves on rockshaft housing - 10 tasks (5.1%)
14. Of the 178 cooling system tasks, the most commonly performed were:
- Rebuild water pumps - 57 tasks (32.0%)
 - Replace fan belt - 26 tasks (14.6%)
15. Of the 323 air conditioning tasks, the most commonly performed were:
- Charge with freon - 72 tasks (28.5%)
 - Evacuate - 76 tasks (23.5%)
 - Replace compressor - 52 tasks (16.1%)
16. Of the 150 preparation tasks, the most commonly performed were:
- Steam clean/wash - 92 tasks (61.3%)
 - Paint - 53 tasks (35.3%)
17. Of the 102 fuel system tasks, the most commonly performed were:
- Replace injection pump - 19 tasks (18.6%)
 - Replace injectors - 11 tasks (10.8%)
18. Of the 63 lubrication system tasks, the most commonly performed was:
- Change oil/filter - 42 tasks (66.7%)
19. Of the 87 engine overhaul tasks, the most commonly performed were:
- Valve job - 28 tasks (32.2%)
 - Replace liners - 9 tasks (10.3%)

20. Of the 74 air and exhaust system tasks, the most commonly performed were:

--Replace air cleaner - 51 tasks	(68.9%)
--Install aspirator - 11 tasks	(14.9%)

21. Of the 58 brake system tasks, the most commonly performed were:

--Adjust brakes - 28 tasks	(48.3%)
--Complete rebuild - 12 tasks	(20.7%)

22. Of the 52 wheel-related tasks, the most commonly performed were:

--Adjust spacing - 14 tasks	(27.0%)
--Mount duals - 10 tasks	(19.2%)

23. Of the 43 tasks involving planters, the most commonly performed were:

--Set-up - 15 tasks	(34.9%)
--Install monitors - 7 tasks	(16.3%)

24. Of the 41 tasks involving primary tillage equipment, the most commonly performed were:

--Service/repair hydraulic system - 7 tasks	(17.07%)
--Set-up - 6 tasks	(14.63%)

25. Of the 32 tasks involving secondary tillage equipment, the most commonly performed was:

--Set-up - 20 tasks	(62.5%)
---------------------	---------

26. Of the 17 tasks involving farmstead equipment, the most commonly performed was:

--Set-up - 7 tasks	(41.2%)
--------------------	---------

27. Of the 14 tasks involving chemical applicators, the most commonly performed were:

--Rebuild pump - 9 tasks	(64.3%)
--Rebuild hydraulic motor - 5 tasks	(35.7%)

28. Of the 1,230 tasks involving the picking unit, unit drive, water system and air system of cotton pickers, the following were performed everytime a picker was overhauled:

--Disassemble picker head	--Recondition and align doffers
--Steam clean	--Replace cabinet seals and bearings
--Paint	--Run in head
--Lube	--Adjust in field
--Level picker bars	
--Recondition and set moistener columns	

29. Of the 11 tasks involving combine heads, the most frequently performed was:

--Set-up platform - 3 tasks (27.3%)

30. A total of 572.7 manhours were devoted to general shop work during the sixth month period studied. This time was used as follows:

--Shop maintenance	102.5 hours
--Vehicle repair	301.4 hours
--Clean up	168.8 hours

CONCLUSIONS

Based upon the findings of this study, the following conclusions have been drawn:

1. While certain mechanical service/repair tasks were performed more frequently than others, the activities of the service department in a modern retail agricultural machinery dealership in central Arizona require service personnel with a broad range of mechanical competencies.
2. Jobs involving power train, electrical, hydraulic, cooling and air conditioning systems represent two-thirds of all tasks performed by mechanics at a major farm machinery dealership serving central Arizona. Nearly two-thirds of all service orders received by these mechanics involve work conducted in-shop. Of the jobs performed in the field, nearly one-half involve air conditioning and hydraulics. Over two-thirds of all service orders involve work conducted on tractors.
3. When developing specialized curricula for secondary programs or post-secondary programs in agricultural power and machinery for Arizona, attention must be given to providing instruction which will assure that students have the opportunity to experience hands-on training which emphasizes the following entry level competencies:
 - a. Troubleshoot electrical systems
 - 1) Operate and maintain test equipment
 - 2) Read and apply circuit schematics
 - b. Remove and replace electrical components
 - 1) alternator/generator
 - 2) battery/battery cables
 - 3) radios
 - 4) injection pump wiring harness
 - 5) injection pump solenoid
 - 6) gauges
 - 7) indicator lights
 - 8) hour meter
 - 9) starter
 - 10) circuit breakers/fuses
 - 11) sending units
 - 12) switches
 - 13) spark plugs
 - 14) starting solenoid
 - 15) starting relay
 - 16) neutral start harness
 - 17) cab relay
 - 18) monitor sensor

c. Repair and/or adjust electrical components

- | | |
|----------------------------|--------------------------|
| 1) Repair radios | 3) Adjust monitor sensor |
| 2) Repair wiring harnesses | 4) Repair lights |

d. Service ignition systems

- | | |
|-------------------|-------------------|
| 1) Time an engine | 2) Set points gap |
|-------------------|-------------------|

e. Service battery

f. Troubleshoot air conditioning systems

- 1) Operate and maintain test equipment

g. Remove and replace air conditioning components

- | | |
|--------------------|--------------------|
| 1) expansion valve | 5) evaporator |
| 2) dryer | 6) condenser |
| 3) lines | 7) compressor/belt |
| 4) hoses/o-rings | 8) blower motor |

h. Evacuate the air conditioning system

i. Charge the air conditioning system with freon

j. Clean the condenser and evaporator

k. Troubleshoot the hydraulic system

- 1) Operate and maintain test equipment

l. Remove and replace hydraulic components

- | | |
|---------------------------------|----------------------------|
| 1) Main pump, bushings and belt | 7) selective control valve |
| 2) rockshaft/rockshaft housing | 8) main valve |
| 3) steering valve | 9) hoses/pipe |
| 4) cylinder | 10) remote cylinder |
| 5) pump | 11) feedback cylinder |
| 6) breakaway couplers | 12) motor mounts |

m. Reseal hydraulic components

- | | |
|----------------------|--------------------|
| 1) main pump | 4) steering pump |
| 2) rockshaft piston | 5) main valve |
| 3) steering cylinder | 6) remote cylinder |

n. Rebuild hydraulic components

- | | |
|----------------------|----------------------------|
| 1) main pump | 4) selective control valve |
| 2) steering valve | 5) remote cylinder |
| 3) steering cylinder | |

o. Adjust hydraulic components

- | | |
|---------------------------------------|----------------------|
| 1) valves on rockshaft housing | 3) steering valve |
| 2) linkage on selective control valve | 4) rockshaft linkage |

p. Change hydraulic fluid/filter

q. Troubleshoot the cooling system

- 1) Operate and maintain test equipment

r. Remove and replace cooling system components

- | | |
|---------------------|------------------------|
| 1) water pump/guard | 4) fan pulley/bearings |
| 2) radiator | 5) thermostat |
| 3) fan/belt | 6) hoses |

s. Check coolant level/solution

t. Rebuild water pump

u. Repair radiator

v. Troubleshoot the clutch

w. Overhaul the clutch. Remove and replace:

- | | |
|-------------|-------------|
| 1) disc | 5) springs |
| 2) seals | 6) bearings |
| 3) bushings | 7) damper |
| 4) plate | |

x. Adjust the clutch

y. Troubleshoot transmission

- 1) Operate and maintain test equipment

z. Overhaul mechanical transmission

- 1) Remove, rebuild and replace the top shaft
- 2) Remove, rebuild and replace the bottom shaft
- 3) Remove, rebuild, replace and adjust shifting linkage
- 4) Remove, rebuild, replace shifting quadrant
- 5) Rebuild two speed pack
- 6) Remove, rebuild and replace front wheel drive shaft

aa. Overhaul hydrostatic transmission

- 1) Remove, rebuild and replace hydrostatic motors
- 2) Remove, rebuild and replace hydrostatic pumps
- 3) Clean sump strainers
- 4) Remove and replace hydrostatic reservoir
- 5) Remove and replace hydrostatic fluid/filter
- 6) Remove and replace hydrostatic drive belts

ab. Troubleshoot power take-offs

ac. Overhaul the power take-off. Remove and replace:

- | | |
|--------------|--------------------|
| 1) shaft | 7) rear gasket |
| 2) bearings | 8) o-ring |
| 3) disc | 9) front seal |
| 4) plate | 10) quill assembly |
| 5) oil lines | 11) brake |
| 6) rear seal | |

ad. Adjust the PTO linkage

ae. Repair the PTO brake

af. Troubleshoot the final drive/differential

ag. Overhaul the final drive/differential. Remove and replace:

- | | |
|-----------------------|--|
| 1) seals/bearings | 10) pinion shaft |
| 2) housing | 11) lock |
| 3) gaskets | 12) disc |
| 4) axle | 13) piston |
| 5) output/input shaft | 14) lock plates |
| 6) couplers | 15) thrust washers |
| 7) spacer | 16) quill |
| 8) cup | 17) Set preload on bearings
in differential |
| 9) ring gears | 18) Set backlash on
differential |

ah. Recondition the planetary pack

ai. Torque axle nuts

aj. Add oil as needed

ak. Assemble farm implements

al. Operate and maintain steam cleaner

am. Select, operate and maintain appropriate spray painting equipment

an. Troubleshoot fuel systems

- 1) Operate and maintain test equipment

ao. Rebuild carburetors

ap. Remove and replace fuel system components

- | | |
|--------------------------------|----------------------|
| 1) fuel lines and check valves | 4) fuel filter |
| 2) injection pump/primer | 5) injectors/washers |
| 3) fuel transfer pump | 6) fuel tanks |

aq. Repair fuel system components

- | | |
|-------------------|--------------|
| 1) throttle | 3) fuel tank |
| 2) injection pump | |

ar. Time injection pump

as. Adjust the throttle

at. Troubleshoot the lubrication system

au. Change oil/filter

av. Adjust oil pressure

aw. Remove and replace lubrication system components

- | | |
|-------------------|-----------------------|
| 1) oil pump | 3) oil cooler o-rings |
| 2) drive assembly | 4) valve tee |

ax. Rebuild oil pump

ay. Replace oil pan gasket

az. Clean oil pan

ba. Troubleshoot multicylinder engines

- 1) Operate and maintain test equipment

bb. Remove and replace engine components

- | | |
|---------------------|----------------------|
| 1) pistons | 6) crankshaft |
| 2) cylinder sleeves | 7) rocker arms |
| 3) connecting rods | 8) push rods |
| 4) head/gasket | 9) front engine seal |
| 5) camshaft | 10) rear engine seal |

bc. Mill engine head

bd. Rebush connecting rods

be. Perform a valve job

bf. Troubleshoot air and exhaust systems

bg. Remove and replace air and exhaust system components

- | | |
|-----------------------------|---------------------------|
| 1) air cleaners | 5) turbocharger-manifold |
| 2) muffler/rain cap | coupler |
| 3) exhaust manifold gaskets | 6) aspirator |
| 4) turbocharger | 7) crankcase outlet valve |

bh. Clean air filters

bi. Troubleshoot the brake system

bj. Remove and replace brake system components

- | | |
|-----------|-----------|
| 1) pads | 4) line |
| 2) disc | 5) spring |
| 3) piston | |

bk. Reline brakes

bl. Adjust brakes

bm. Troubleshoot tires and wheels

bn. Remove and replace tires and wheel-related items

- | | |
|----------------|------------------------|
| 1) duals | 5) wheel weights |
| 2) sleeve half | 6) front wheel spindle |
| 3) tubes | 7) wheel bearings |
| 4) hub | 8) wheel |

bo. Adjust wheel spacing

bp. Fill tires with ballast

bq. Repair tires

br. Align front wheels

bs. Pack bearings

bt. Set up planters

bu. Adjust planters

bu. Remove and replace planter components

- | | |
|----------------------|---------------------------|
| 1) monitor sensors | 5) tubes |
| 2) disc cappers | 6) levers on seeder boxes |
| 3) gauge wheel crank | 7) drag chains |
| 4) closing wheel | 8) grass seeder |

bw. Repair monitors

bx. Repair monitors

by. Remove and replace primary tillage components

- | | |
|---------------|-----------------|
| 1) moldboards | 5) trash boards |
| 2) shins | 6) shanks |
| 3) landsides | 7) shank points |
| 4) frogs | |

bz. Remove, repair and replace remote hydraulic cylinders

ca. Set up secondary tillage equipment

cb. Remove, repair and replace remote hydraulic cylinders

cc. Remove and replace secondary tillage components

- | | |
|-----------|--------------|
| 1) sweeps | 2) stop kits |
|-----------|--------------|

cd. Set up farmstead equipment

ce. Rebuild hydraulic motors for chemical applicators

cf. Rebuild pumps for chemical applicators

cg. Overhaul cotton picker heads

- | | |
|--------------------------------------|--|
| 1) disassemble picker head | 17) recondition pressure plates |
| 2) replace and/or align grid bars | 18) replace flaps on pressure plates |
| 3) replace spindles/bushings | 19) replace wear angles |
| 4) replace picker bar bushings/studs | 20) replace skid plates |
| 5) level picker bars | 21) replace stalk lifters |
| 6) recondition picker bars | 22) replace cabinet seals and bearings |
| 7) install sleeves on bars | 23) steam clean head |
| 8) replace cam arms | 24) paint |
| 9) replace drum heads | 25) lube |
| 10) replace grease tubes | 26) run in head |
| 11) replace top drive gear | 27) adjust in field |
| 12) replace sun gears | |
| 13) replace idle gears and bearings | |
| 14) recondition doffers | |
| 15) align doffers | |
| 16) replace doffer drive chains | |

ch. Overhaul unit drive countershaft

- 1) replace belts
- 2) replace countershafts
- 3) replace U-joints

ci. Overhaul air system

- 1) replace air ducts
- 2) replace blower belts

cj. Overhaul water system

- 1) recondition moistener columns
- 2) remove and replace unit water pump

ck. Attach combine heads

cl. Set up combine platforms

cm. Adjust cylinder speeds

cn. Overhaul combine head

- 1) replace rasp bars
- 2) replace beater
- 3) replace rear cross auger
- 4) replace auger drive countershaft and bearings

co. Maintain a clean and orderly work area.

4. To aid in developing curriculum, the tasks identified through the job analysis are now placed in a format to express the total instructional program for agricultural power and machinery.

Knowledge	Skills
<u>Equipment Efficiency (Calibration)</u>	
1. Principles of machine calibration.	1a. Calibrating seeding rate for grain drills. b. Calibrating seeding rate for corn planters c. Adjusting corn planter check row mechanism for drop rate.
2. Wheel slippage calibration.	2a. Calculating per cent wheel slippage.

Knowledge	Skill
3. Spray nozzle theory.	3a. Calibrating application rate for weed sprayers.
4. Theory of dusting.	4a. Calibrating dusters for rate of application.
5. Principles of fertilizer placement.	5a. Calibrating bulk fertilizers rate of application.
6. Characteristics of granular material.	6a. Calibrating granular insecticides and fertilizer applicators for rate of application.
7. Efficiency factors of harvesting equipment.	7a. Determining harvesting efficiency of a combine. b. Determining harvesting efficiency of a corn picker.
8. Test equipment used for determining RPM.	8a. Calibrate operating RPM of machine parts.

Electrical System

9. Principles of electricity.	9a. Applying Ohms Law to direct current circuits. b. Applying safety procedures.
10. Electrical components.	10a. Replacing and adjusting electrical components.
11. Electrical circuit schematics.	11a. Interpreting circuit schematics.
12. Principles of ignition timing.	12a. Servicing ignition components. b. Adjusting ignition timing.
13. Spark plug selection.	13a. Servicing spark plugs.
14. Battery selection.	14a. Testing battery condition.
15. Types and function of electrical test equipment.	15a. Operating and maintaining test equipment.

Air Conditioning System

16. Principles of air conditioning.	16a. Applying safety procedures. b. Interpreting service manual specifications. c. Interpreting circuit diagrams.
17. Types of refrigerants and oils.	17a. Selecting refrigerants and oils.

Knowledge	Skill
18. Air conditioning components.	18a. Replacing air conditioning components.
	19a. Cleaning the condenser and evaporator.
	b. Evacuating the air conditioning system.
	c. Charging the air conditioning system.
20. Types and function of air conditioning test equipment.	20a. Operating and maintaining air conditioning test equipment.
	21a. Trouble shooting compressor and evaporator components and electric circuits.

Hydraulic System

22. Principles of hydraulic system operation.	22a. Applying safety practices.
	b. Interpreting service manual specifications.
	c. Interpreting schematics.
23. Characteristics and functions of hydraulic oils.	23a. Selecting hydraulic oils.
24. Hydraulic components.	24a. Replacing hydraulic components.
	b. Adjusting hydraulic components.
25. Characteristics of hydraulic pumps.	25a. Repairing hydraulic pumps.
26. Types and function of control valves.	26a. Repairing control valves.
27. Types and function of cylinders.	27a. Repairing cylinders.
28. Types of hydraulic hose and fittings.	28a. Replacing hose fittings.
29. Types and function of filters.	29a. Replacing system filters.
30. Types and function of hydraulic test equipment.	30a. Operating and maintaining hydraulic equipment.

Power Train

31. Principles of power train operation.	31a. Applying safety practices.
	b. Interpreting service manual specification.

Knowledge	Skills
32. Types and functions of drives.	
33. Types and functions of gears.	
34. Types and functions of bearings.	
35. Types and functions of clutches.	35a. Adjusting the clutch. b. Overhauling the clutch.
36. Types and functions of transmissions.	36a. Adjusting mechanical and hydrostatic transmissions. b. Overhauling mechanical and hydrostatic transmissions.
37. Mechanical transmission components.	37a. Servicing mechanical transmission components.
38. Hydrostatic transmission components.	38a. Servicing hydrostatic transmission components.
39. Shift controls.	39a. Adjusting shifting linkage.
40. Types and function of test equipment.	40a. Operating and maintaining test equipment.
41. Principles of torque converter operation.	41a. Diagnosing torque converter problems.
42. Torque converter components.	42a. Overhauling torque converter.
43. Principles of differential operation.	43a. Diagnosing differential problems.
44. Differential locks.	
45. Differential adjustments.	45a. Setting preload pinion/bevel gear mesh and backlash.
46. Differential components.	46a. Overhauling the differential.
47. Types and function of final drives.	47a. Diagnosing final drive problems.
48. Final drive adjustments.	48a. Adjusting axle bearings.
49. Final drive components.	49a. Overhauling the final drive.
50. Types and functions of PTOs.	50a. Diagnosing PTO problems.

Knowledge	Skills
51. PTO adjustments.	51a. Adjusting PTO drive to operating dimension.
52. PTO components.	52a. Overhauling the PTO U-joints.
	53a. Servicing rotating shields.

Cooling System

54. Cooling system components.	54a. Servicing cooling system components.
	b. Rebuilding water pumps.
	c. Repairing radiators.
55. Cooling system test equipment.	55a. Operating and maintaining cooling system test equipment.

Fuel Systems

56. Fuel system components (diesel and gas).	56a. Replacing fuel system components.
	b. Timing the injection pump.
	c. Rebuilding the carburetor.
	d. Adjusting the throttle.
	e. Adjusting engine governor speed control to specifications.
57. Fuel system test equipment.	57a. Operating and maintaining fuel system test equipment.

Lubrication System

58. Lubrication system components.	58a. Replacing lubrication system components.
	b. Rebuilding oil pumps.
59. Selection of oil and filters.	59a. Changing oil/filters.
60. Oil pressure.	60a. Adjusting oil pressure.
61. Lubrication system test equipment.	61a. Operating and maintaining lubrication system testing equipment.
	62a. Interpreting oil analysis data.

<u>Knowledge</u>	<u>Skills</u>
of multicylinder operation.	63a. Applying safety practices. b. Interpreting service manual specifications. c. Diagnosing engine problems.
components.	64a. Replacing, repairing, adjusting and/or cleaning engine compo- nents or assemblies (i.e., head, block, piston, crankshaft, and timing assemblies and their component parts).
component.	65a. Perform power test with PTO dynamometer.
<u>Air and Exhaust System</u>	
system	66a. Replacing air and exhaust system components.
<u>Brakes</u>	
brake components.	67a. Rebuilding brakes. b. Adjusting brakes.
<u>Tires and Wheels</u>	
power transfer.	68a. Selecting tires by size. b. Setting wheel spacing.
wheel slippage/ requirements.	69a. Hanging dual wheels and single wheels.
bearing lubricants.	70a. Packing bearings.
<u>Small Tractor Drills</u>	
drills and feeding devices.	72a. Adjusting seed gates and metering wheels.
seed metering	73a. Servicing and repairing disc bearings. b. Aligning seed and fertilizer drop tubes for proper placement.
set-up and owner's specifications.	74a. Adjusting lifting linkage and hitch height.

75a. Setting-up small grain drills.

Row Crop Planter

76. Type and function of planters.

77. Selection of seed plates.

78a. Servicing and adjusting hill drop and check row mechanism.

79a. Adjusting furrow openers and covering discs.

80a. Adjusting lifting linkage.

81a. Repairing monitors.

82a. Setting-up row crop planters.

Primary Tillage Equipment

83. Types and function of primary tillage equipment.

84. Primary tillage equipment components.

84a. Setting up primary tillage equipment.

b. Adjusting line of draft.

c. Spacing wheel width.

d. Adjusting hitch components.

Secondary Tillage Equipment

85. Types and functions of secondary tillage equipment.

86. Secondary tillage equipment components.

86a. Adjusting shovels and sweeps.

b. Adjusting lifting and lowering linkage.

c. Installing stop kits.

Farmstead Equipment

87. Types and function of farmstead equipment.

88. Farmstead equipment components.

88a. Setting up and adjusting farmstead equipment.

Knowledge	Skills
<u>Weed Sprayers</u>	
89. Types of nozzles and pumps.	89a. Adjusting spray patterns. b. Servicing and repairing pressure regulators, pumps, nozzles and screens. c. Selecting nozzle sizes.
<u>Dusters</u>	
90. Types of dusters.	
91. Distribution of dust particles.	91a. Adjusting feed rate of duster. b. Adjusting distribution vanes and hose. c. Adjusting operating speed of fan.
<u>Anhydrous Ammonia Applicators</u>	
92. Types of injection pumps.	92a. Servicing and repairing metering pumps. b. Adjusting metering pumps to ground speed.
	93a. Servicing heat exchanger.
<u>Cotton Picker</u>	
94. Types of cotton pickers.	
95. Picking units.	95a. Overhauling picking units. b. Maintaining picking units. c. Adjusting picking units.
96. Water system.	96a. Overhauling the water system. b. Maintaining the water system. c. Adjusting the water system.
97. Air system.	97a. Overhauling the air system. b. Maintaining the air system.

Knowledge	Skills
<u>Combine</u>	
98. Nature and types of harvesting and threshing machines.	
99. Systems of the combine harvester.	99a. Aligning and repairing cutter bar. b. Adjusting platform components. c. Adjusting reel controls. d. Replacing cylinder bars. e. Adjusting and replacing concave bars. f. Repairing and adjusting cleaning shoes. g. Adjusting the straw spreader. h. Adjusting cylinder speed. i. Attaching heads.
<u>Swather</u>	
100. Operating principles of swather.	100a. Aligning the cutter bar. b. Installing and adjusting conveyor canvas. c. Servicing and adjusting crimper rolls. d. Adjusting pick-up fingers. e. Adjusting reel height.
<u>Mower</u>	
101. Types of mowers and their construction characteristics.	
102. Types of cutter bars.	102a. Repairing, servicing and adjusting cutter bars. 103a. Servicing and adjusting sickle activating parts. 104a. Adjusting bar tilting and lift mechanisms.

Knowledge	Skills
<u>Baler</u>	
105. Types and characteristics of balers.	
106. Basic operation of wire and twine tie balers.	106a. Service and adjust pick-up attachment. b. Service and adjust packer unit. c. Adjust plunger to bale chamber. d. Adjust and replace plunger and stationary knife. e. Replace bale retainer dogs.
107. Principles of knotter operation.	107a. Adjust, service and repair twine knotter head. b. Adjust, service and repair wire tie twist mechanism. c. Time knotter head to plunger. d. Time needles to plunger. e. Replace and adjust needles to knotter and bale chamber. f. Adjust size and weight of bales. g. Troubleshoot tying process.